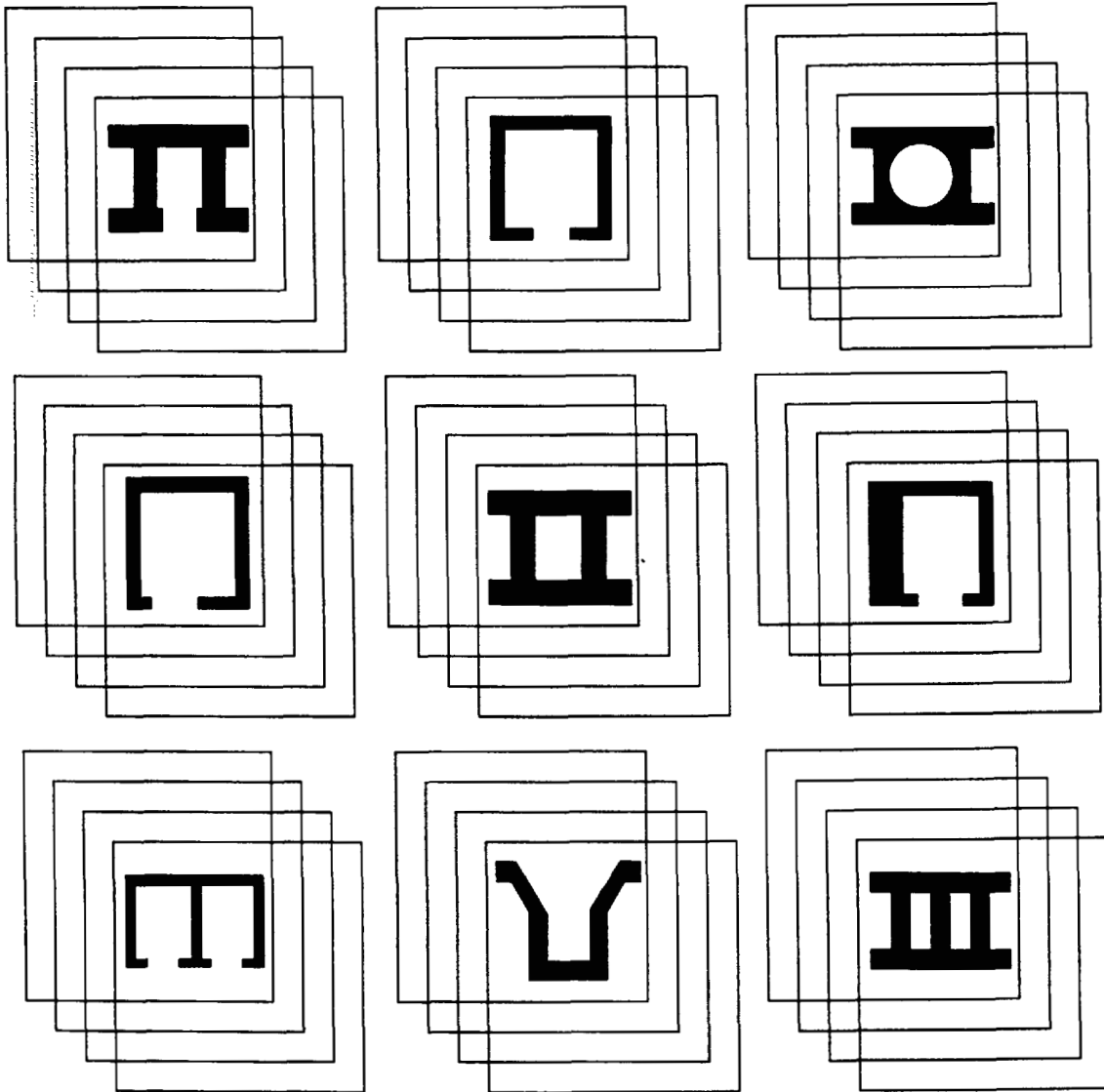


Understanding Aluminum Extrusion Tolerances

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About The Aluminum Association

The Aluminum Association represents primary and secondary producers of aluminum, as well as semi-fabricated products.

Member companies operate approximately 400 plants in 30 states.

The Association's mission is to increase understanding of aluminum and the aluminum industry and increase aluminum's use through its' technical, statistical, marketing and informational activities and services. The Association's programs are designed to serve its customers, consumers, educators, students, government and the public generally.

For the aluminum industry and its customers, the Association develops standards and designation systems, prepares codes and specifications involving aluminum products and addresses technical and marketing issues for the industry. The Association is the leading source of statistics for the aluminum industry.

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Understanding Aluminum Extrusion Tolerances

This publication explains and illustrates many aspects of the published standard tolerances for aluminum alloy extrusions, such as those contained in *The Aluminum Association's Aluminum Standards and Data* and the *American National Standard Dimensional Tolerances for Aluminum Mill Products*, ANSI H35.2. These standards are maintained by The Aluminum Association, the latter on commission by the American National Standards Institute (ANSI).

The tolerances published in *Aluminum Standards and Data* and in ANSI H35.2 result from the voluntary consensus standards development process prescribed by ANSI. Hence, the existence of the standards do not preclude an individual or organization from manufacturing, marketing, purchasing, or using products not conforming to the tolerances covered by the standards and discussed in this publication.

The publication and the videotape upon which it was based were developed under the guidance of a technical task force of The Aluminum Association's Extruded Products Division, which sponsored their production. While the task force used its best efforts to ensure the accuracy of the content, the task force, the Extruded Products Division, and The Aluminum Association do not warrant, guarantee, or otherwise assume any responsibility for the use of the information provided in any specific application.

This publication, *Understanding Aluminum Extrusion Tolerances*, was originally written as a supplement for a 30-min video with the same title. The section and page numbers used in the publication were intended as references to sections of that videotape; in using the publication by itself, those designations have no special significance. The videotape *Understanding Aluminum Extrusion Tolerances* is still available for purchase from The Aluminum Association at the address printed inside the front cover.

Acknowledgement is made to Aluminum Association consultants Stan Benjamin and Paul V. Mara for valuable technical assistance with the project leading to this publication and the associated videotape.

APPENDIX

C.1 Extrusion Forms

C.1-1

Hollow Shapes C.4

Solid Shapes C.5, C.6

Semihollow Shapes C.6, C.7, C.8

Definitions of Products

In determining the general configurations of desired shapes, note the several basic classifications: solids, semihollow, hollow, etc. These shapes are all producible, but for economic consideration, solid shapes are most economical with costs increasing for the hollow shapes for both metal and tooling. The produc-

er's engineering and design personnel can be of assistance in re-designing, if needed, shapes which will fulfill the desired function, yet reduce overall costs. However, even the most intricate extruded shapes may often still be the most economic solution to your specific need.

Extrusion: An extrusion is a product formed by pushing metal through a die.

Extruded Shape: An extruded shape is a wrought product that is long in relation to its cross sectional dimensions and has a cross section other than that of sheet, plate, rod, bar, tube or wire.

Solid Extruded Shape: Any extruded shape other than a hollow or semihollow shape. Example, Figure 1.

Extruded Rod: A solid extrusion whose cross section is round, and whose diameter is 0.375-inch or greater. Smaller sizes are classified as wire.

Extruded Bar: A solid extrusion whose cross section is symmetrical and is square or rectangular with sharp or rounded corners or edges, or is a regular hexagon or octagon, and whose width between parallel faces is 0.375-inch or more. Smaller sizes are classified as wire.

Semihollow Extruded Shape: An extruded shape, any part of whose cross section partially encloses a void, in which the ratio of the area of the void to the square of the gap width is greater than the value shown in Table 1.



Figure 1



$$\frac{\text{Area of the Void In Square Inches}}{\text{Square of the Gap In Inches}} = \text{Ratio}$$

Gap Width Inches	CLASS 1		CLASS 2	
	Group A Alloys ①	Group B Alloys ②	Group A Alloys ①	Group B Alloys ②
				Ratio ③
0.040--0.062	2.0	1.5	2.0	1.0
0.063--0.124	3.0	2.0	2.5	1.5
0.125--0.249	3.5	2.5	3.0	2.0
0.250--0.499	4.0	3.0	3.5	2.5
0.500--0.999	4.0	3.5	3.5	2.5
1.000--1.999	3.5	3.0	3.0	2.0
2.000 and over	3.0	2.5	3.0	2.0

① Group A alloys are 1060, 1100, 1350, 3003, 5454, 6061, 6063

② Group B alloys are 2011, 2014, 2024, 5083, 5086, 5456, 6066, 7001, 7075, 7178, 7079

③ See Figure 6 for typical methods of figuring ratios

Table 1: Classification--Semihollow Extruded Shapes



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Semihollow Shapes C.6

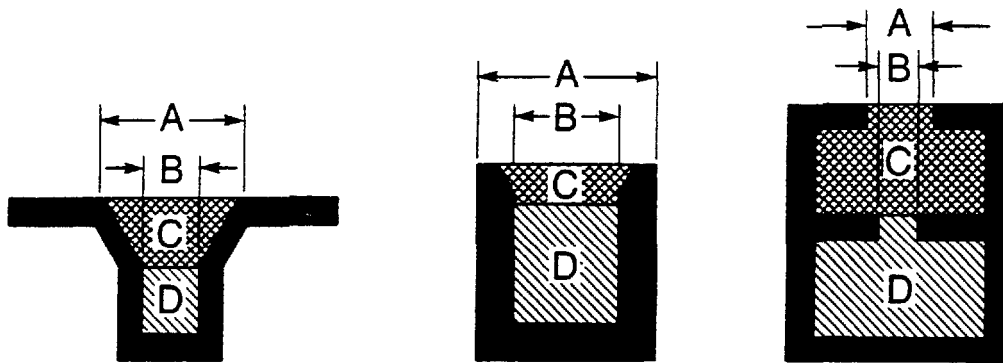


Figure 2: Typical Semihollow Extruded Shapes. Use Void Area D and Gap Width B or Void Areas C and D and Gap Width A, Whichever Results in Larger Ratio.

Class 1 Semihollow Extruded Shape: A semihollow extruded shape of two voids or less which in the area of the voids and surrounding metal thickness is symmetrical about the centerline of the gap. Example, Figures 3 and 4.

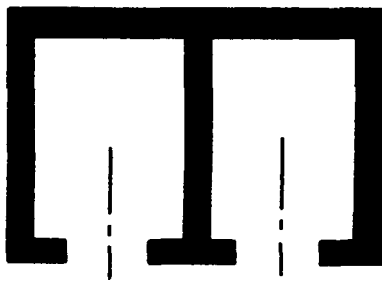


Figure 3: Typical Class 1, Semihollow Extruded Shape

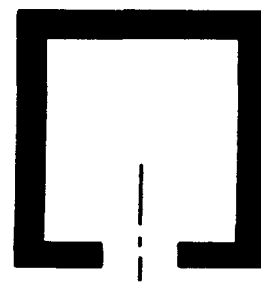


Figure 4: Typical Class 1, Semihollow Extruded Shape

Class 2 Semihollow Extruded Shape: Any semihollow extruded shape other than Class 1. Example, Figures 5 and 6.

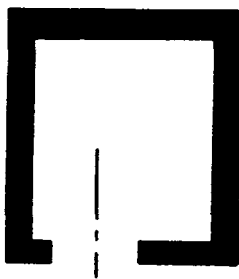


Figure 5: Typical Class 2, Semihollow Nonsymmetrical Void, Symmetrical Surrounding Metal Thickness

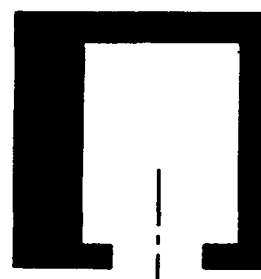


Figure 6: Typical Class 2 Semihollow Symmetrical Void, Non-symmetrical Surrounding Metal Thickness

Hollow Shapes C.4

Hollow Extruded Shape: An extruded shape, any part of whose cross section completely encloses a void.

Class 1 Hollow Extruded Shape: A hollow extruded shape whose void is round and one inch or more in diameter and whose weight is equally distributed on opposite sides of two or more equally spaced axes. Example, Figure 7.

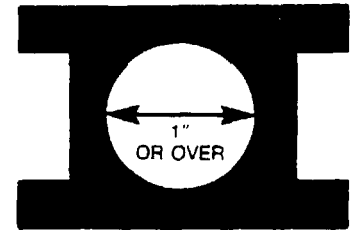


Figure 7: Class 1 Hollow Extruded Shape

Class 2 Hollow Extruded Shape: Any hollow extruded shape other than Class 1 which does not exceed a 5-inch circumscribing circle and has a single void of not less than 0.375-inch diameter or 0.110 square inch area. Example, Figure 8.



Figure 8: Class 2 Hollow Extruded Shape

Class 3 Hollow Extruded Shape: Any hollow extruded shape other than Class 1 or Class 2. Example, Figure 9.



Figure 9: Class 3 Hollow Extruded Shape

Tube: A hollow section that is long in relation to its cross-section, which is symmetrical and is round, square, rectangular, hexagonal, octagonal, or elliptical, with sharp or rounded corners, and having uniform wall thickness except as affected by corner radii.

Drawn Tube: A tube having final dimensions produced by drawing through a die.

Extruded Tube: A tube produced by hot extrusion.

Pipe: A tube having certain standardized combinations of outside diameter and wall thickness, commonly designated by *Nominal Pipe Sizes* and *ANSI (American National Standards Institute) Schedule Numbers*.

(This information adapted from: *Drafting Standards for Aluminum Extruded and Tubular Products*, The Aluminum Association, Washington, DC, 1981)



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APPENDIX

D.2 Individual Tolerances

D.2-1

Importance of Determining Tolerances Individually

In examining extruded product specifications, it may sometimes appear that if certain specifications are within standard tolerances, they should guarantee the accuracy of others as well. **It is never safe to make that assumption.**

It is very important to determine and inspect each applicable standard tolerance individually, independent of all others.

Consider, for example, a simple extruded channel of alloy 6063 with these dimensions and the standard tolerances indicated by Tables 11.2 (Cross-Sectional Dimension Tolerances) and 11.12 (Angularity) in ASD, 1988. See Figure 1.

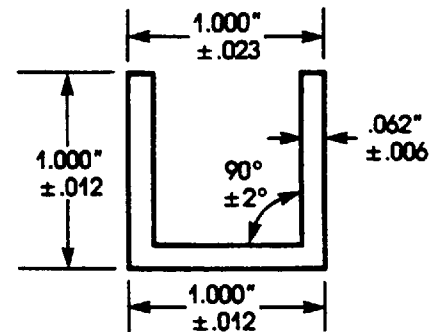


Figure 1

Even in this simple shape, several dimensions can be comfortably within tolerance, while another is not. Example 1, Figure 2.

In this example, the bottom and sides of the channel are all 0.012" less than their specified dimension of 1.000", while the top-outside measures 0.023" more than its specified dimension of 1.000" and angle at the left measures exactly 90 degrees.

All of those dimensions are within their standard tolerances. But the angle at the right, then, must be 92 degrees, 2 minutes -- 2 degrees, 2 minutes larger than specified and 2 minutes larger than its allowable tolerance.

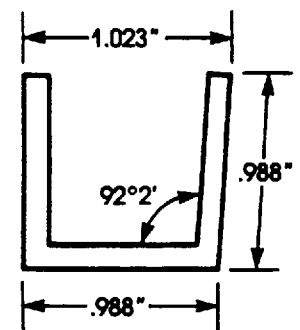


Figure 2

In Example II, Figure 3, the sides and bottom each measure 1.000", exactly as specified. Each angle is 91 degrees, one degree larger than specified, but well within the ± 2.0 -degree tolerance allowed by ASD Table 11.12.

But the top-outside dimension is 1.035 inches, which is 0.012-inch larger than the allowed tolerance of $1.000'' \pm 0.023$.

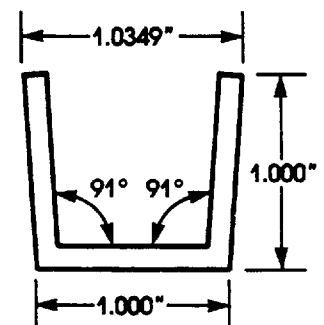


Figure 3

As the figures in Example III, Figure 4 make clear, angularity in this shape can be far out of tolerance even if all of the perimeter linear dimensions are exactly as specified. In fact, the angles can take on any value at all, while the perimeter remains within tolerance!

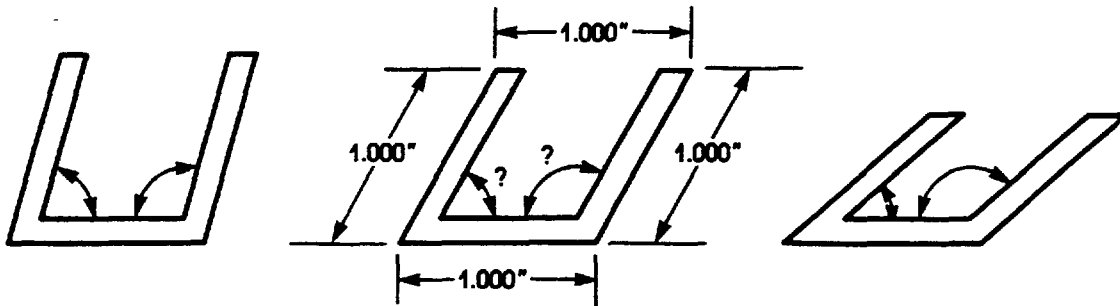


Figure 4

Many other examples could be provided, but the point remains the same: each tolerance must be determined and inspected independently of other tolerances.

APPENDIX

G.1 Flatness Tolerancing

G.1-1

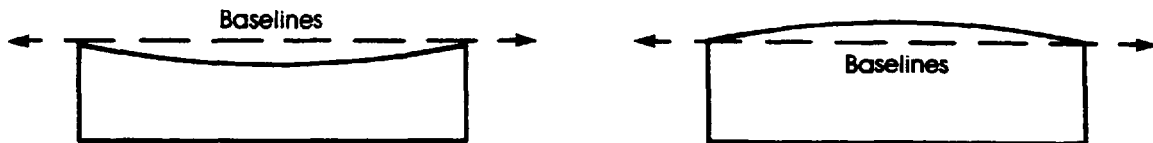
What A Flatness Tolerance Means

If a surface width of an extrusion is intended to appear in cross section, as a straight line, a standard tolerance for flatness applies to that width.

That means that this surface, measured in cross-section at any location along the extrusion, may not deviate from a perfectly straight line by more than the

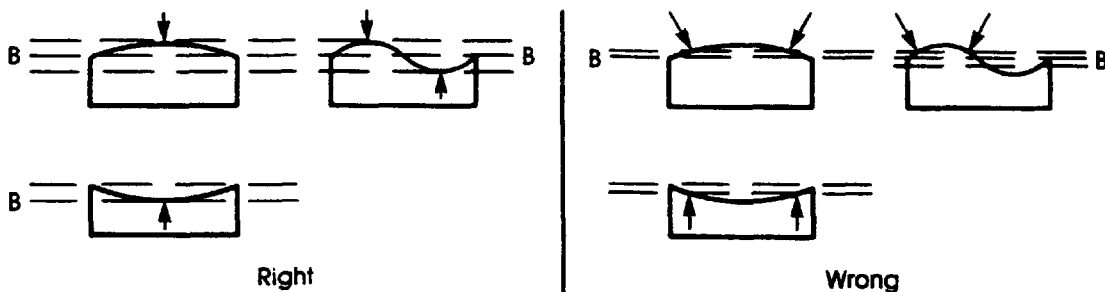
amount allowed for its width --the tolerance values.

The baseline for flatness tolerancing is the ideal straight line connecting the two end points of the profiled surface (in effect, an ideal flat plane, seen end-on). See Figure 1.

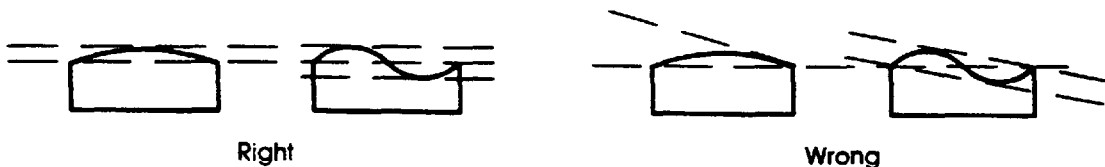
**Figure 1**

The profiled plane must lie entirely within two planes which:

1. Just touch, but do not penetrate, (are tangent to) the surface on either side of the baseline (see Figure 2);

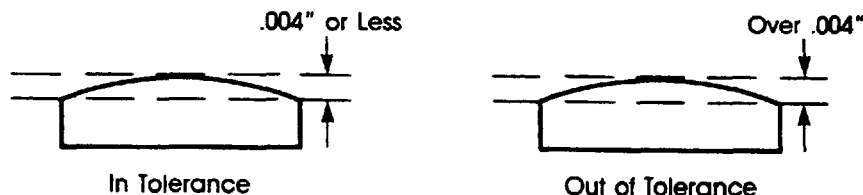
**Figure 2**

2. Are parallel to the baseline (see Figure 3);

**Figure 3**

3. And are separated by a distance no greater than the allowed tolerance.

If tolerance = .004 inch:

**Figure 4****Documents**

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In summary: deviations from flatness must be contained between two tangential planes parallel to a baseline representing the ideal flat surface. The flatness tolerance limits the maximum distance between these planes.

If deviations from perfect flatness lie entirely to one side of the baseline, then the baseline itself becomes identical with one of the two limiting planes:

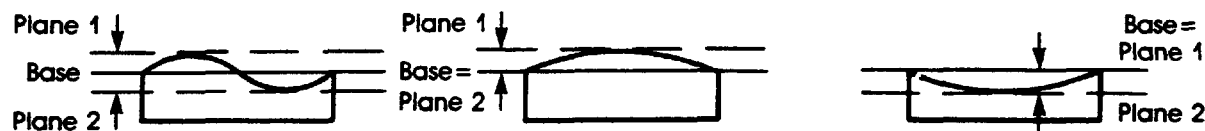


Figure 5

The extruded flatness tolerance tables in Aluminum Standards and Data are illustrated, for simplicity and clarity, with shapes displaying concave deviations from flatness.

But it does not matter whether the "flat" surface has a concave deviation that dips "inside" the ideal shape of the solid metal or a convex deviation that bulges "outside" the ideal shape.

The principle is the same: the deviation is measured from the baseline connecting the ends of the tolerated width, see Figure 6.

Flatness Tolerances for Solid and Semihollow Shapes

The flatness tolerances for surfaces of extruded bar, solid shapes and semihollow shapes are given in ASD Table 11.6.

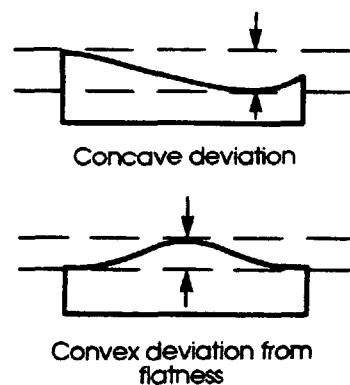
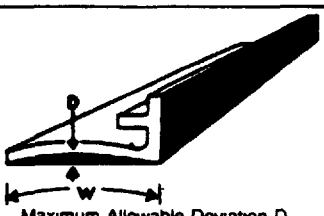


Figure 6

TABLE 11.6 Flatness (Flat Surfaces) ^①	
BAR, SOLID SHAPES AND SEMIHOLLOW SHAPES EXCEPT FOR SHAPES IN 0, T3510, T4510, T6510, T76510 and T8510 TEMPER ^②	
SURFACE WIDTH in.	TOLERANCE—in.
	 Maximum Allowable Deviation D
Up thru 1	.004
Over 1 thru 5.999	.004 × W (in.)
In any 1 in. of width	.004

Note that three tolerances are imposed: a minimum tolerance for surfaces no wider than one inch; a total tolerance over the entire width; and a unit tolerance in any one inch of width.

APPENDIX

G.4 Flatness: Narrow Surfaces

G.4-1

Narrow-Surface Flatness Tolerance

Table 11.6 allows a deviation from perfect flatness of up to .004 inch on any width up through 1.000 inch.

This means, for example, that a surface 0.5 inch wide is allowed a flatness deviation of .004 inch; so is a surface 0.8 inch wide, or 1.000 inch wide -- or any other width less than one inch.

To put it another way, a surface is allowed 0.004 inch flatness deviation regardless of its specific width, as long as that width is no greater than one inch.

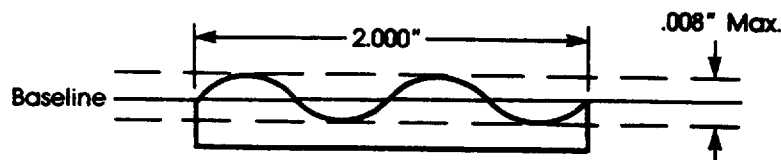
APPENDIX

G.5 Flatness: Total-Width Tolerance G.5-1**Total-Width Flatness Tolerance**

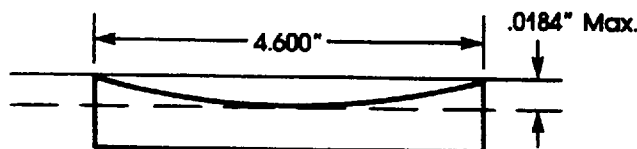
Table 11.6 allows a total maximum deviation from flatness of: 0.004 inch times the width of the surface in inches. The baseline for this measurement is the straight line connecting the extreme ends of the tolerated surface.

This applies to surfaces wider than one inch but not wider than 5.999 inches.

For example, a surface 2.000 inches wide may deviate around its full-width baseline by no more than a total of .008 inch ($2.000 \times .004 = .008$). See Figure 1.

**Figure 1**

A surface 4.600 inches wide may deviate no more than a total of 0.018 inch ($4.600 \times .004 = 0.0184$). See Figure 2.

**Figure 2**

Surfaces wider than 5.999 inches are not given a standard total flatness tolerance (in that case the total flatness tolerance will be as agreed between purchaser and vendor).